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MODELING PROTOCOL

Southwestern Public Service Company Harrington Station Power Plant in Potter County Texas

Task 3: Site-Specific Modeling Protocols for the 2010 One-Hour SO_2 NAAQS

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1. Introduction

Atmospheric and Environmental Research (AER) has been tasked to perform regional 1-hour SO_2 modeling for the Harrington Power Plant (Harrington) facility in Potter County, as part of a State Implementation Plan analysis to define a National Ambient Air Quality Standard (NAAQS) non-attainment area.

2. Air Quality Model Overview

As stated in 40 CFR Appendix W, EPA's AERMOD v19191 model will be used for this study along with various preprocessors: AERMINUTE v15272 to include measured one-minute wind averages; AERSURFACE v13016 to determine the surface characteristics for the meteorology station; AERMAP v180881 to gather elevation data for a nested receptor grid; AERMET v19191 to generate meteorological data files; and BPIPPRM v04274 to provide building downwash effects to the modeling scenario.

3. Facility Overview

The Harrington facility is located in Potter County, Texas. Figure 1 shows the facility with a satellite imagery background. The buildings are in green, the property boundary in blue, and the sources in yellow are labeled with text in white.

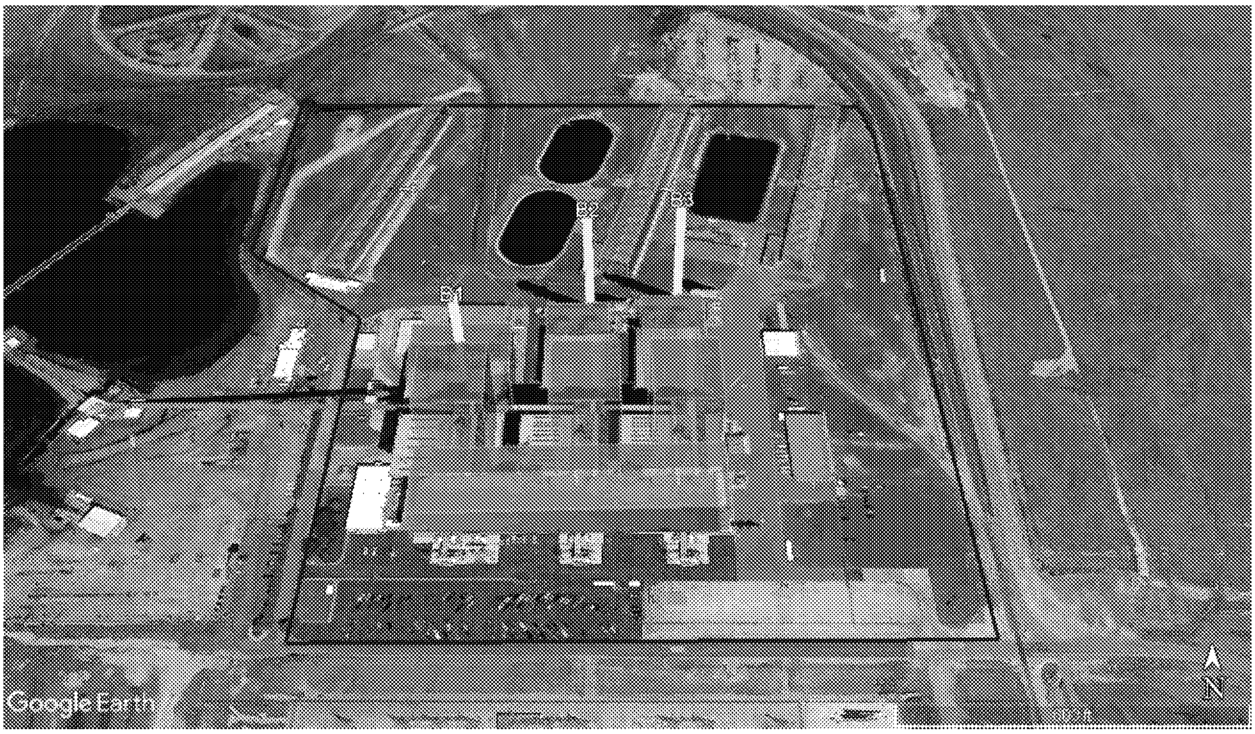

Figure 1: Facility Overview

Figure 2 shows the modeling overview with a 20-kilometer (km) radius circle around the facility, the meteorology stations, and the nearby monitors.

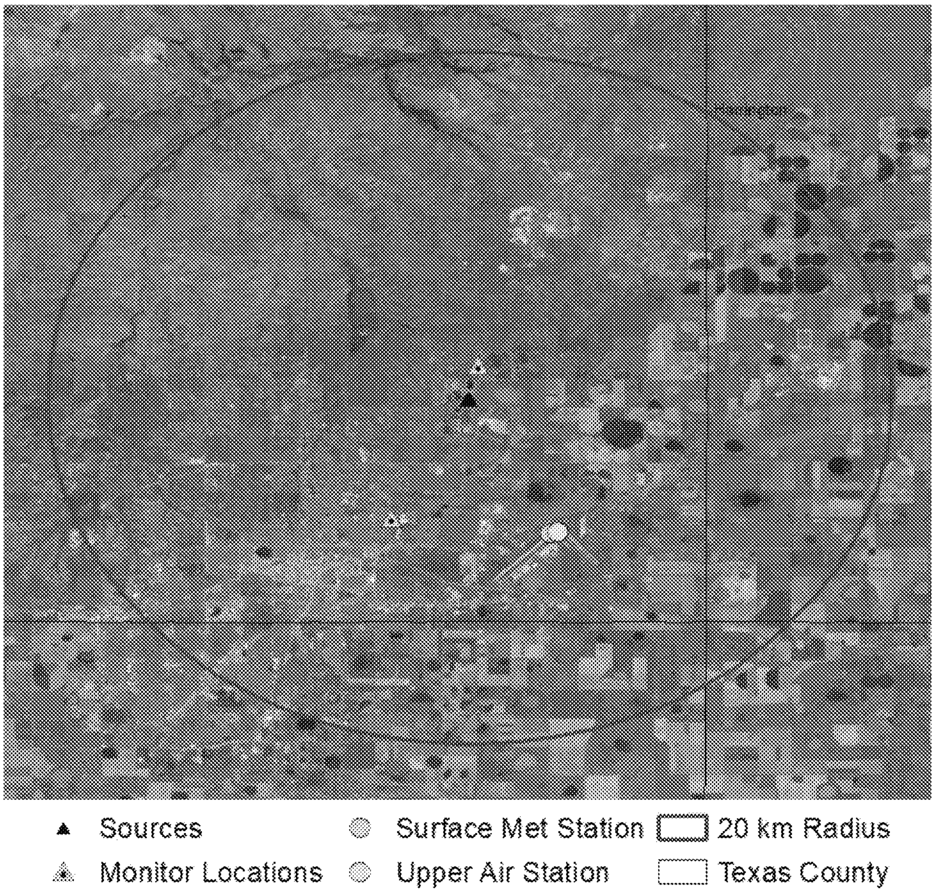

Figure 2: Domain Overview

4. Receptors

Receptor elevations are from USGS National Elevation Data (NED) at 30-meter resolution and processed by AERMAP. The NED data are tiled data based on latitude and longitude approximately 100 km x 100 km. All tiles necessary to cover the modeling domain will be downloaded and processed. The receptors consist of 2 nested grids centered around the facility. The inner most nest goes from the center of the facility out to 5 kilometers with a grid spacing of 100 meters. The second and outermost grid goes from 5 km to 20 km with a grid spacing of 500 meters. In addition to the nested grid there are receptor points added at the locations of the nearby monitors and receptor points located at 25-meter intervals along the property line shown in Figure 1. All nested receptors within this property boundary have been removed. Figure 3 and 4 show the near and far receptors respectively.

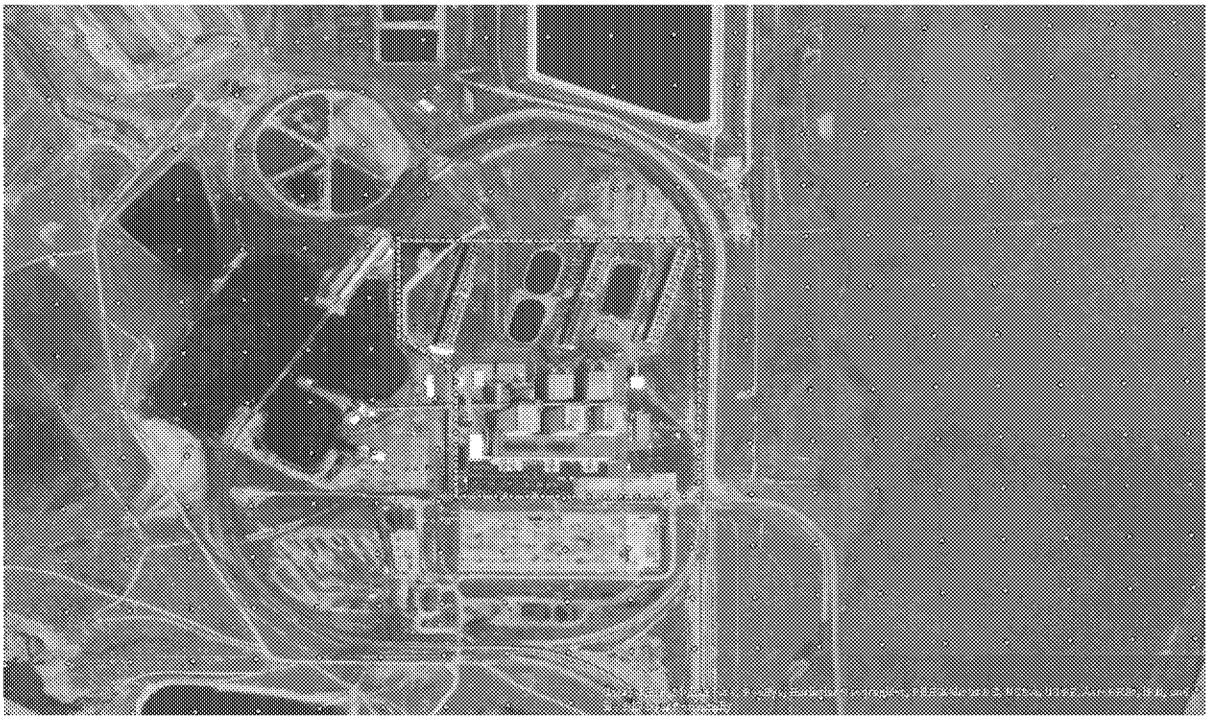

Figure 3: Receptor Field Near the Facility

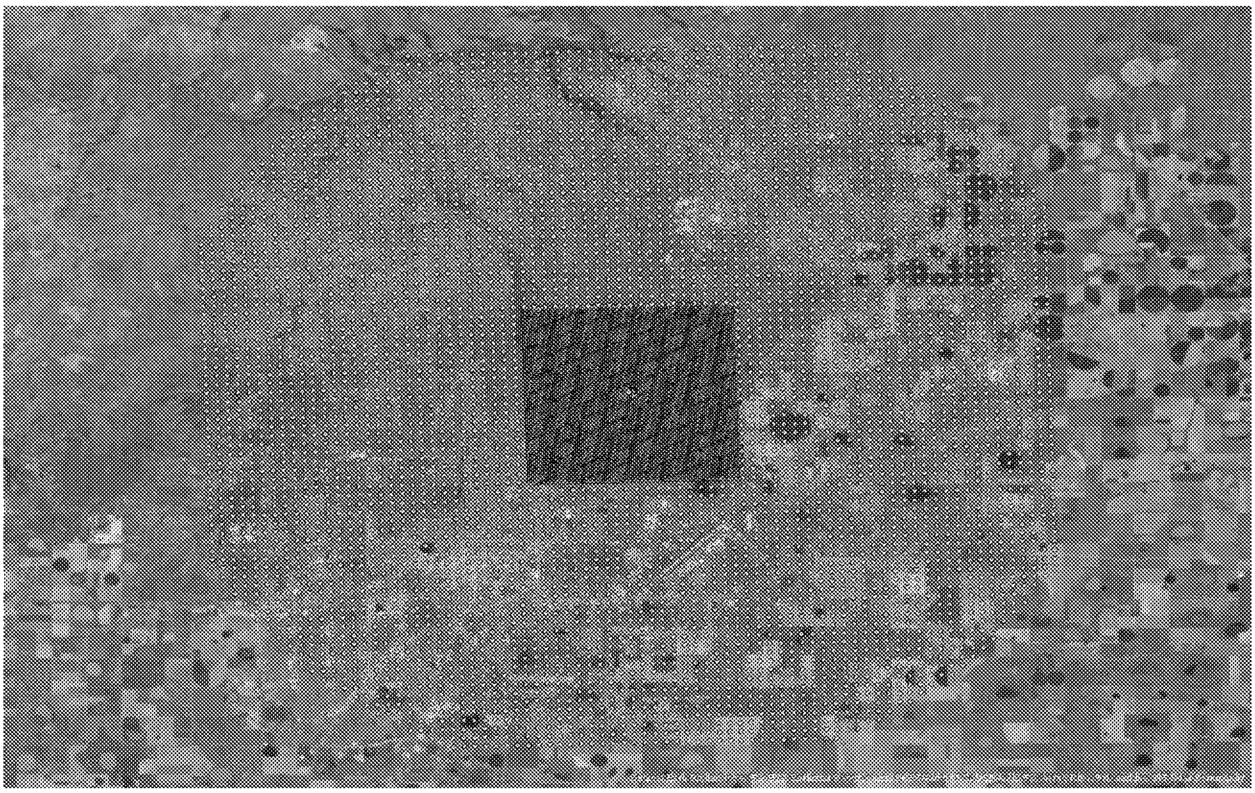

Figure 4: Complete Receptor Field Centered on the Facility

5. Meteorology Data

Meteorology data were processed for the years 2016-2018 providing 3 years of data to determine a SO_2 design value. The surface and upper air data used were from the Amarillo Airport (WBAN 23047). Sub-hourly one-minute wind data from Amarillo was also processed with AERMINUTE. Table 1 and Table 2 provide the completeness of the processed meteorology data for the surface and upper air stations respectively.

Table 1: Surface Station Data Completeness Statistics

Year	Temperature	Wind Direction	Wind Speed	Acceptable
2016	99.83%	98.36%	99.81%	Yes
2017	99.9%	97.86%	99.86%	Yes
2018	99.65%	98.3%	99.59%	Yes

Table 2: Upper Air Station Data Completeness Statistics (Normal 2 soundings per day 0Z and 12Z ~ 730 per year. Sometimes there are additional soundings done.)

Year	Valid Soundings	Acceptable
2016	740	Yes
2017	755	Yes
2018	739	Yes

AERMET requires albedo, bowen ratio, and surface roughness for modeling purposes. The pre-processor AERSURFACE is used to calculate these parameters using 1992 National Land Cover Data. A radius of 1 km is selected for this study as well as the maximum 12 sectors. To derive these surface characteristics, we also determine surface seasonal categories for each month based on the descriptions in Table 3. For instance, a winter with snow cover (CAT 4) will have a very different albedo and surface roughness than summer with lush vegetation (CAT 1). Monthly seasonal determination was calculated based in large part by how many days during the month were below 32°F using the default categories as a starting point. For example, March and April are usually characterized as spring (CAT 5). If the number of days below freezing for that month was above 16, the category was changed to winter (CAT 3). Table 3 lists the default categories and Table 4 lists the logic in determining the category adjustment based on the number of days below freezing. Some months are not adjusted as they fall in the middle of the usual season and are therefore assumed not to change.

Table 3: AERSURFACE Seasonal Category Descriptions and Defaults

Category	Description	Default
1	Midsummer with lush vegetation	Jun, Jul, Aug
2	Autumn with unharvested cropland	Sep, Oct, Nov
3	Late autumn after frost and harvest, or winter with no snow	Dec, Jan, Feb
4	Winter with continuous snow on ground	
5	Transitional spring with partial green coverage or short annuals	Mar, Apr, May

Table 4: Monthly Category Determination Criteria

Month	Adjustment Criteria	Adjusted Category
March, April	> 16 days below freezing	3
May	March < 5 days below freezing	1
June	April > 10 days below freezing	5
August	September > 5 days below freezing	2
October, November	> 16 days below freezing	3

Winter with continuous snow on ground (CAT 4) was determined using NOAA's daily snow depth observations[1]. If a month had over half of the days with greater than one inch of snow it had a seasonal category of 4. No months for this area were categorized as winter with snow. The seasonal categories for each year were determined separately, however we suggest using the same categories for all months except if there is snow. Table 5 shows the categories used in running AERSURFACE.

Table 5: Seasonal Categories used in AERSURFACE

Month	Seasonal Category Used	Default Category	Days Below Freezing		
			2016	2017	2018
January	3	3	21	18	26
February	3	3	16	14	19
March	5	5	5	6	6
April	5	5	0	0	4
May	5	5	0	1	1
June	1	1	0	0	2
July	1	1	0	0	0
August	1	1	0	0	0
September	2	2	0	0	0
October	2	2	0	1	1
November	2	2	6	6	13
December	3	3	26	25	22

1 http://www.nohrsc.noaa.gov/nsa/reports.html?region=National&var=snowdepth&dy=2018&dm=1&dd=31&units=e&sort=value&filter=0

We also determine whether each modeled year is wet, dry, or average based on yearly precipitation for the Amarillo Airport (WBAN 23047) during the past 30 years from NCDC[2]. Year classifications were determined if the annual precipitation was above the top 30th percentile (22.07 inches, wet), below the bottom 30th percentile (17.2 inches, dry) or in the middle 40th percentile (between the other values, average). Table 6 lists the precipitation data and resulting classification.

Table 6: Precipitation Classification for AERSURFACE.

Year	Annual Precipitation (inches)	Classification
1990	17.53	
1991	15.94	
1992	20.65	
1993	18.34	
1994	16.56	
1995	18.34	
1996	20.53	
1997	24.99	
1998	17.18	
1999	26.99	
2000	18.41	
2001	18.72	
2002	18.28	
2003	13.44	
2004	27.34	
2005	15.02	
2006	21.91	
2007	22.54	
2008	22.43	
2009	21.17	
2010	26.55	
2011	7.02	
2012	12.35	
2013	15.22	
2014	19.41	
2015	34.66	
2016	**17.21**	**Average**
2017	**26.49**	**Wet**
2018	**13.63**	**Dry**
2019	25.91	

[2] https://www.ncdc.noaa.gov/cdo-web/search

6. Background Data

SO_2 background data are needed for this modeling study. The nearest monitor to this facility is Amarillo Xcel El Rancho about 2 km northeast of the facility (ID 1077). It started operating in Q4 of 2016; data for quarter 4 of 2019 is not completely verified, but initial values are used and summarized below in Table 7 along with the next closest monitor (1025). Table 8 shows the total capture rates of monitors 1025 and 1077. Data for the entire month of July 2019 is missing for monitor 1077.

Table 7: Nearby Monitors and Calculated 99th Percentile Values by Year

Monitor ID	Distance from Facility (km)	County	2017 99th Percentile (ppb)	2018 99th Percentile (ppb)	2019 99th Percentile (ppb)
1025	7.8	Potter	15.5	11.5	8.0
1077	2	Potter	114.4	132.7	95.4

Table 8: Monitor 1025 and 1077 Total Capture Rates

Monitor	2017	2018	2019	Acceptable
1025	98.22%	95.7%	95.05%	Yes
1077	96.97%	95.65%	86.9%	No

Table 8 shows unacceptable coverage of monitor 1077, however further analysis was done to see if it was being affected by the Harrington facility. We removed the hourly monitor values where the monitor was downwind of the facility (meaning a 90-degree range around the direction directly downwind) and then recalculated the 99th percentile values. For monitor 1077, any wind direction between 150 and 240 degrees was removed as the monitor is northeast of the facility. A total of 9,062 hours (37%) were removed as being affected by the nearby sources. Two pollution roses are provided in Figure 5 showing the prevailing winds for the surface station as well as the SO_2 concentrations with those winds ranges.

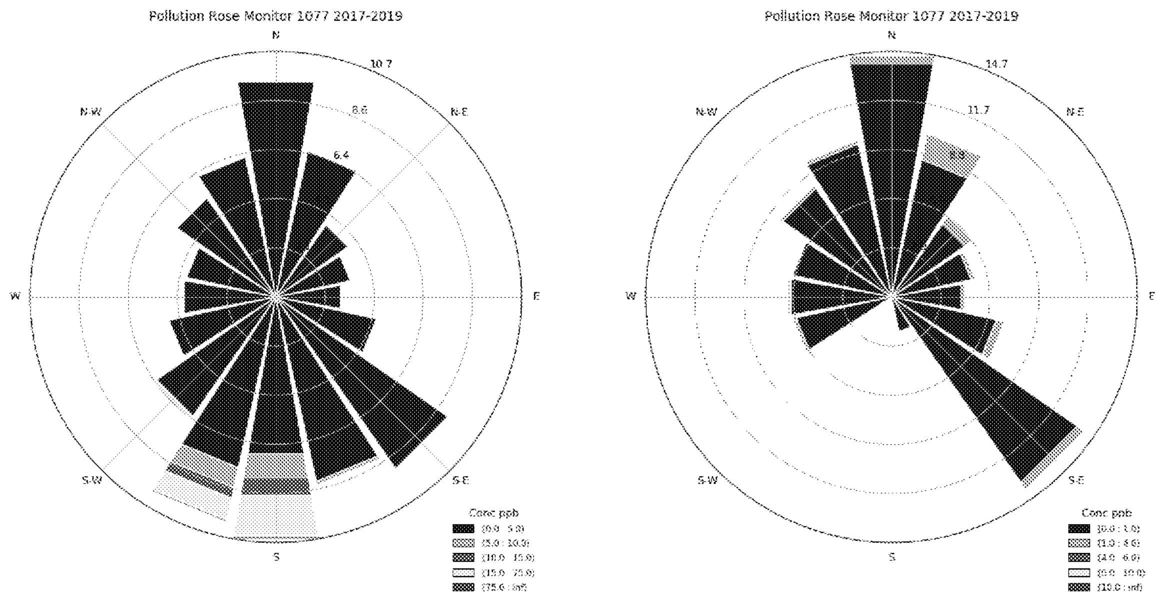

Figure 5: Pollution rose including all hours (left), Pollution rose with affected hours removed (right)

After removing the affected hours, the resulting design value is 11.9 ppb. Figure 5 (right) shows a greatly reduced range of concentrations (1-4 ppb) from that of Figure 5 (left) as a majority of the higher concentrations were impacts from the local sources. It is inferred that the resulting design value being 11.9 ppb must still be impacted by local sources. Therefore, monitor 1077 is not a representative background site.

We then looked at Texas monitors specifically purposed to measure population exposure. A list of these can be found in the TCEQ 2016 Annual Monitoring Network Plan[3]. The closest one to the facility is monitor 1025, which is listed in Table 7 and Table 8 with a design value of 11.66 ppb and acceptable coverage respectively. Figure 6 shows the pollution rose for monitor 1025 having a majority of the concentration values below 5 ppb. The only hint of higher concentrations are when the wind is blowing from northeast, which is the direction of the local sources.

[3] https://www.tceq.texas.gov/assets/public/compliance/monops/air/annual_review/historical/2016-AMNP.pdf

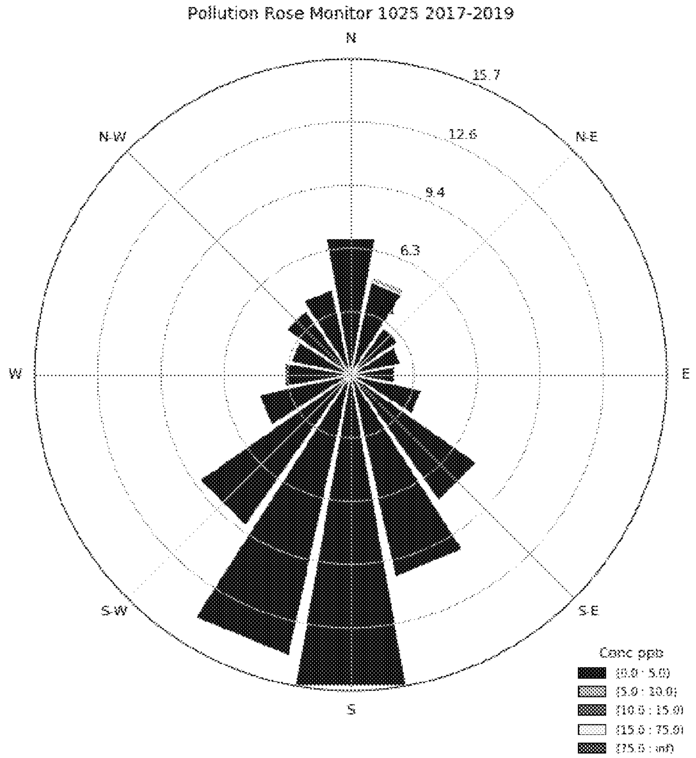

Figure 6: Pollution Rose for Monitor 1025

With the nearest monitors being affected by the local sources, we looked further out at the next closest monitor located in Austin, Texas (monitor 0014). Table 9 shows the capture rates, and Table 10 shows the 99th percentile values for monitor 0014. This monitor is not affected by any nearby SO_2 sources and has acceptable capture rates. We will use 2.6 ppb as a background value for this modeling study.

Table 9: Monitor 0014 Capture Rates

Year	Q1 Capture	Q2 Capture	Q3 Capture	Q4 Capture	Overall Capture	Acceptable
2017	95.5%	96.8%	96.2%	97.6%	96.53%	Yes
2018	95.8%	96.5%	84.3%	97.3%	93.48%	Yes
2019	97.0%	95.8%	98.1%	98.1%	97.25%	Yes

Table 10: Monitor 0014 99th Percentile Results

Year	99th Percentile (ppb)
2017	3.5
2018	2.4
2019	1.9
Design Value	**2.6**

7. Modeled Sources

The facility has six sources emitting SO_2. The State of Texas Air Reporting System (STARS) data were searched within 20 km of the Harrington facility to identify any other potential sources. This would include any facility with total annual emissions greater than 100 tpy regardless of the individual sources' size. In this case there are no other facilities or sources fitting these parameters. Some of these sources will not be modeled as they are emergency units with limited use and very low annual emissions compared to the main sources. All modeled sources and parameters are shown in Table 11, while the sources not modeled are in Table 12 with the last column stating the reason they are not modeled.

Table 11: Modeled Facility Source Parameters

SRC ID	Model ID	Latitude	Longitude	HT (m)	Diameter (m)	Temp (K)	Velocity (m/s)
UNIT 1	UNIT1	35.298953	-101.747972	76.196	5.773	394.261	27.034
UNIT 2	UNIT2	35.299503	-101.747078	91.436	5.791	394.261	27.034
UNIT 3	UNIT3	35.299592	-101.746411	91.436	5.791	394.261	27.034

Table 12: Non-modeled sources and parameters with description of why it wasn't modeled.

SRC ID	Model ID	Latitude	Longitude	HT (m)	Diameter (m)	Temp (K)	Velocity (m/s)	Reasoning
EG	EG	35.298097	-101.748283	3.048	0.229	644.261	24.688	Emergency Unit
EG-2	EG2	35.298289	-101.747519	3.048	0.229	644.261	24.688	Emergency Unit
EG-3	EG3	35.298203	-101.746033	3.048	0.229	644.261	24.688	Emergency Unit

Hourly emission values were found for the three modeled sources using the Continuous Emissions Monitoring[4] (CEMS) site provided by the EPA. As such, an hourly emissions profile will be created using this data and used in AERMOD. Table 13 shows the annual total emissions of the modeled sources for reference, and annual emission for the non-modeled sources are provided in Table 14. These values are from the STARS data provided by the TCEQ.

[4] https://www.epa.gov/emc/emc-continuous-emission-monitoring-systems

Table 13: Annual total emissions from STARS data for modeled sources

SRC ID	Model ID	Avg. Emissions 2016 tpy	Avg. Emissions 2017 tpy	Avg. Emissions 2018 tpy
UNIT 1	UNIT1	3794.4871	3513.5	3615.9902
UNIT 2	UNIT2	5071.564	4762.3106	5223.9785
UNIT 3	UNIT3	5382.1779	4604.5	3567.2095

Table 14: Annual total emissions from STARS data for non-modeled sources

SRC ID	Model ID	Avg. Emissions 2016 tpy	Avg. Emissions 2017 tpy	Avg. Emissions 2018 tpy
EG	EG	0.0154	0.0083	0.0138
EG-2	EG2	0.019	0.0099	0.014
EG-3	EG3	0.0157	0.0145	0.0156